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Aluminum Nitride Insulating Films for MOSFET Devices

The results of an investigation of the electrical properties of metal-insulator-metal (MIM) capacitor structures indicate that insulating films of aluminum nitride (AlN), having thicknesses of the order of 10^{-5} mm, could be useful in charge-storage devices, possibly of the configuration MIMOS-FET. The films are sufficiently conductive at high fields to permit charging and discharging of a buried metal gate with relatively low short-voltage pulses (about 10 V across the AlN film for 10^{-7} sec or less). Of great interest is the fact that the films are also sufficiently insulating at lower values of electric field to store charges for periods of at least three weeks to possibly one year.

Au-AlN-Al structures were prepared by nitriding freshly-deposited aluminum films in a nitrogen glow discharge with a spatial gradient intensity, and then evaporating a large number of gold counter-electrodes to form structures having insulator thicknesses over a wide range of values.

Currents in Au-AlN-Al structures were found to be a function of applied voltage and insulator thickness separately, rather than of electric field alone (as for a bulk-limited process). Currents are relatively independent of temperature and, for insulator thicknesses greater than about 40×10^{-7} mm, relatively symmetrical with respect to the polarity of applied voltage. Over the whole range of applicable voltage, three different dependences of current on applied voltage can be observed: For low voltages, the current is linearly dependent on voltage; for intermediate voltages, the current increases more rapidly with

voltage, and for higher voltages, the current increases even more rapidly.

In the operation of a MIMOS-FET, the MIM capacitor structure would be charged in as short a time as possible. The results of a series of experiments in which the capacitor structures were charged in a time period of 10^{-7} second showed that the discharge currents responsible for decays were markedly different than those expected from steady-state current-voltage relationships. It became evident that traps exist in AlN and that their degree of occupancy strongly affects the conductivity of the insulator. Since trap-filling is a relatively slow process, steady-state current-voltage characteristics would be expected to differ from instantaneous characteristics. The nonlinear characteristics suggest the use of AlN films in MIM capacitors.

Reference:

Lewicki, G. and Maserjian, J.: Electrical Characteristics of AlN Insulating Films in the Thickness Range 40 to 150 Å. Metallurgical Transactions, vol. 2, March 1971, p. 673.

Patent status:

No patent action is contemplated by NASA.

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